

**PLUG POWER FUEL CELL DEMONSTRATION PROJECT
UNITED STATES MILITARY ACADEMY (USMA)
WEST POINT, NY**

Mid-Point Project Description Report

March 5, 2004

Prepared for

**U.S. ARMY CORPS OF ENGINEERS
CONSTRUCTION ENGINEERING RESEARCH LABORATORY (CERL)**
Champaign, Illinois

Mr. Frank Holcomb
Technical COR

Prepared by

PLUG POWER INC.
Latham, New York

Brian Davenport
Project Manager

In accordance with Contract Number:
DACA42-02-C-0025

Overview

This report shall serve as the midpoint project status update for the U.S. Military Academy – West Point fuel cell demonstration program pursuant to DACA42-02-C-0025. Topics covered will include documentation of the installation process including completed site photos and performance data through October 2003.

Objectives

The installation and operation of PEM fuel cells at the United States Military Academy (USMA) – West Point, NY has objectives that further the missions the U.S. Army Corps of Engineers, the USMA and Plug Power. The following points summarize the common high-level objectives for this program:

- Allow assessment of fuel cells in supporting sustainable military installations;
- Increase the Army's ability to more efficiently construct, operate and maintain its installations;
- Assess the role of PEM fuel cells in supporting the Army's training, readiness, mobilization, and sustainability missions;
- Provide a technology demonstration site for military base market;
- Provide operational testing & validation of product to assess installation, grid interconnection, operation of systems in all seasonal conditions, and integration of units into an existing military base environment.
- Provide an understanding of military requirements in applications utilizing CHP and standby capabilities.

Plug Power, a New York State designer and manufacturer of Proton Exchange Membrane (PEM) fuel cells has extensive experience in the design and operation of PEM fuel cell systems since its inception in 1997. Plug's focus on natural gas powered fuel cell systems has resulted in the successful demonstration of systems with increasing reliability, reduced cost, and increasing functionality. Plug Power fuel cells have been sold to, and operated for New York State Energy Research and Development Authority, General Electric, DTE Energy Technologies, and the Long Island Power Authority. In addition, Plug Power has operating experience of integrated fuel cell systems of over 250,000 hours in laboratory, field demonstration, and prototypical environmental applications. Plug Power's initial approach to the marketplace is targeting electric and gas utility customers as well as government customers. This program supports Plug Power's recognition of the Department of Defense as a potentially significant customer for fuel cells in the future, and provides the opportunity for an initial assessment of the use of PEM fuel cells supporting military base infrastructure.

Equipment

Plug Power Inc. manufactured, installed and is currently operating a total of three (3) GenSys™ 5CS - 5kW PEM fuel cell systems for one year at the USMA. The natural gas powered fuel cell systems provide electricity to the facility and incorporate combined heat and power (CHP) capability that allows waste heat to be recovered from the fuel cell and used to supplement the existing domestic hot water and space heating systems. Additionally, the fuel cell systems include standby capability that will allow the units to operate during periods of electric utility grid (Grid) outage such as that experienced in August 2003. Product specifications for the fuel cells installed can be found in Table 1.

Table 1: Product Specifications

Comment	Specification
Unit Size	Base Unit with integral skid: 74”L x 32”W x 68”H (excludes 22” exhaust stack)
Installation Location	Outdoor
Grid Parallel	Yes (w/ standby capability)
Power Output/Set points	2.5kW, 4 kW, 5 kW
Remote monitoring capability	Via phone line
Output Voltage	120 VAC @ 60 Hz
Certification	Integrated System CSA International Listed; Inverter UL Listed
Power Quality	IEEE 519 or better
Emissions (steady-state)	NOx < 5 ppm Sox < 1 ppm CO < 50 ppm
Standard operating conditions	Temperature: 0 °F to 104 °F Elevation: up to 6,000 ft Noise: < 65 dBa @ 1 meter

Installation

The United States Military Academy (USMA) in West Point, NY is the home and training ground of the future leaders of the U.S. Army. Plug Power and USMA personnel identified three (3) residential sites within the campus for the fuel cell installation– specifically:

- 221A Lee Rd, Lee Housing Area – LTC Boettner
- 290B Lee Rd, Lee Housing Area – LTC Massie
- 76A Schofield Place, Lusk housing area – COL Nygren

Each site has one (1) fuel cell system:

- The systems are configured for standby power generation mode where the systems will continue to power the residence in the event of a power (grid) outage. Each tenant was allowed to select five circuits in their existing panel that they would like to keep powered. These circuits were switched over to a new critical load panel that was installed at each site.
- Thermally, the fuel cells are integrated to support/supplement the existing domestic and hot water heating needs of the sites. BTU meters were installed at each site in order to measure the amount of heat transferred from the fuel cell into the site host’s hot water system. In addition, space-heating elements (baseboard heat, forced hot-air unit) were installed and monitored in order to study the effectiveness and efficiency of the CHP loop for this type of application.

Plug Power retained Industrial Process Design, Inc. (IPDI) for their engineering and general contracting services during the installation phase of this project. The scope of work included development of an engineering package containing all details of site construction, foundation preparation, installation of the natural gas, water and CHP systems, electrical interconnection and all miscellaneous piping, conduit, wiring and

construction coordination activities. All work was performed under a lump-sum contract for a total of \$51,100 or approximately \$17,000 per system. IPDI held two sub-contracts for completion of the electrical and mechanical work. An installation timeline showing major milestones can be found in Table 2.

Table 2: Installation Timeline

Completion date	Task
November 27, 2002	Contract signed by all parties
November 28, 2002	Start site engineering
December 13, 2002	Foundation preparation for fuel cell placement
December 16, 2002	System delivery and rigging
January 4, 2003	Engineering package completed and approved by Plug Power and USMA
March 3, 2003	Start electrical construction
March 5, 2003	Start mechanical construction
March 18, 2003	Finish mechanical construction
March 21, 2003	Finish electrical construction
April 24, 2003	Preventative maintenance on systems to address potential issues from extended cold weather storage
April 25, 2003	Installation of protective, wooden pipe covers
April 25, 2003	Initial system start-ups
May 2, 2003	Commissioning of fuel cell systems

Site Photographs

221A Lee Rd (LTC Boettner)



290B Lee Rd (LTC Massie)



76A Schofield Pl. (COL Nygren)



Typical Utility Penetration



Performance Data

Table 3 shows the fleet performance data for the first 6-months of unit operation (through October 31, 2003). For individual system performance data, refer to the attached spreadsheet [USMA Mid pt operational data.xls](#). Total harmonic voltage distortion (THD) measurements were taken in July 2003 as required by the contract. Results of the THD test can be found in Table 4.

Table 3: Fleet Data

Run Time (Hours)	12876.95
Time in Period (Hours)	13128
Availability (%)	98.09%
Energy Produced (kWe-hrs AC)	32237.32
Output Setting (kW)	2.50
Average Output (kW)	2.50
Capacity Factor (%)	49.11%
Fuel Usage, LHV (BTUs)	4.49E+08
Fuel Usage (SCF)	443918.8787
Electrical Efficiency (%)	24.51%
Thermal Heat Recovery (BTUs)	10804000
Heat Recovery Rate (BTUs/hour)	839.02
Thermal Efficiency (%)	2.41%
Overall Efficiency (%)	26.92%
Number of Scheduled Outages	4
Scheduled Outage Hours	12.5
Number of Unscheduled Outages	10
Unscheduled Outage Hours	238.6

Table 4: Total Harmonic Distortion Measurements

Location	Unit	THD (Voltage)	Date	Technician
221A Lee Rd. (LTC Boettner)	178	0.7%	7/2/2003	J. Morawski
76A Schofield Pl. (COL Nygren)	179	1.4%	7/2/2003	J. Morawski
290B Lee Rd. (LTC Massie)	180	0.8%	7/2/2003	J. Morawski

Points of Contact

Plug Power, Inc.

Brian Davenport, Market Engagement Manager

(518) 782-7700 x1939

brian_davenport@plugpower.com

USMA – West Point, NY

LTC Darrell Massie, Associate Professor - Department of Civil and Mechanical Engineering

(845) 938-4037

Darrell.Massie@usma.edu